THE NATURE CONSERVANCY NEWS

March/ April 1980

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THE NATURE CONSERVANCY NEWS

VOLUME 30, NUMBER 2
MARCH/APRIL, 1980

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COVER: In pre-settlement times, the gray wolf thrived throughout most of North America. Today, south of Canada, there remains only one major population of this endangered predator. Photo by Phil and Judy Sublett.

The Nature Conservancy is a national conservation organization committed to the preservation of natural diversity by protecting lands containing the best examples of all components of our natural world.

To date the Conservancy and its members have been responsible for the preservation of 1,591,503 acres of forests, marshes, prairies, mountains, and islands: home to rare and endangered species of wildlife and plants. 2,259 projects have been completed since the acquisition of the first preserve in 1954. Approximately 60% of all preserves are retained by the Conservancy and managed by volunteer land stewards.

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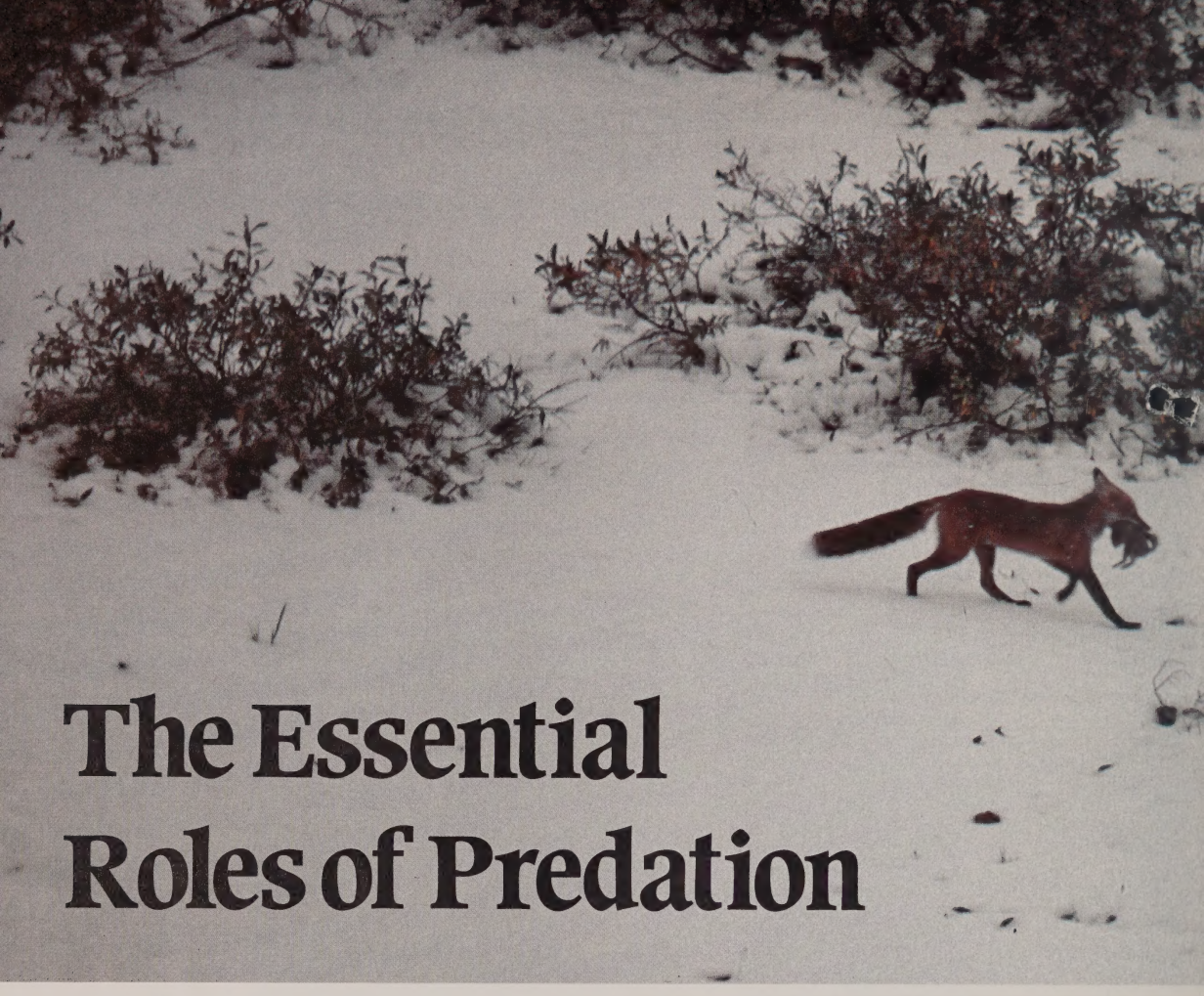


The Essential Roles of Predation

by Durward L. Allen

We are in a century of significant "explosions." One of them is in the field of information. Biologists will affirm this, and with their expanding comprehension has come a signal realization: the structure and functioning of living organisms are the most complex phenomena we know anything about in the universe.

Among mysterious unknowns, some elemental facts seem clear. No form of life exists alone. Each is dependent on a plant-animal community of which it is a working member. There are no free riders, no unemployment. One way or another, in its living and its dying, every species contributes to the cycling of nutrients—the basic process that produces new generations and makes possible the awesome drama of survival.

The flow of energy through an ecosystem (a life community plus its physical environment) takes many paths. One such route is the feeding by meat-eaters on the herbivores. Historically, people have had oversimplified ideas about predation, and this kind of thinking is still with us. We tend to adopt cliches and plausible explanations that lead us astray.

A notable example is the so-called balance of nature—often overworked in discussions of predator-prey relations. Actually, the expression is helpful if you take for granted that balance does not mean stability. Biocommunities are in a constant state of change. The numbers and productivity of plants and animals fluctuate with variations in weather, water level, and biotic factors—such things as plant succession, grazing or browsing pressure, and the spread of disease. A balance does exist, but it is the containment of changes within limits that reliably fall short of destroying the ecosystem.

Various investigators and natural philosophers have achieved a growing perception of predator habits since Darwin, Wallace, Agassiz, Marsh, and other pioneers of the 1800's began sketching in the outlines of an orderly system of nature. It became evident that the meat-eaters have

community functions (niches) essential to many different plans of survival.

On this continent the early 1900's brought extensive inventories of animal life to find out what we had, after which the studies became more ecologically sophisticated. Since 1960 research on the predators has increased substantially, and field workers are filling in the fine print under some good ideas, theories, and principles.

The Question of Control

An early assumption relative to the role of small predators—hawks, owls, foxes, weasels, and the like—was that they controlled the numbers of their prey. Since the prey often were rodents injurious to agriculture, the idea converted into an economic justification for protecting small predators. When "plagues" of mice or lemmings occurred and attracted large numbers of gulls and other mobile feeders, the control function seemed verified.

A disturbing question was, how did the plagues (the proper term is irruption) happen in the first place? We may have an incomplete answer. When food supply, weather, and other important conditions are favorable, no amount of hunting by the local contingent of predators will stop an irruption of rapidly breeding voles or lemmings.

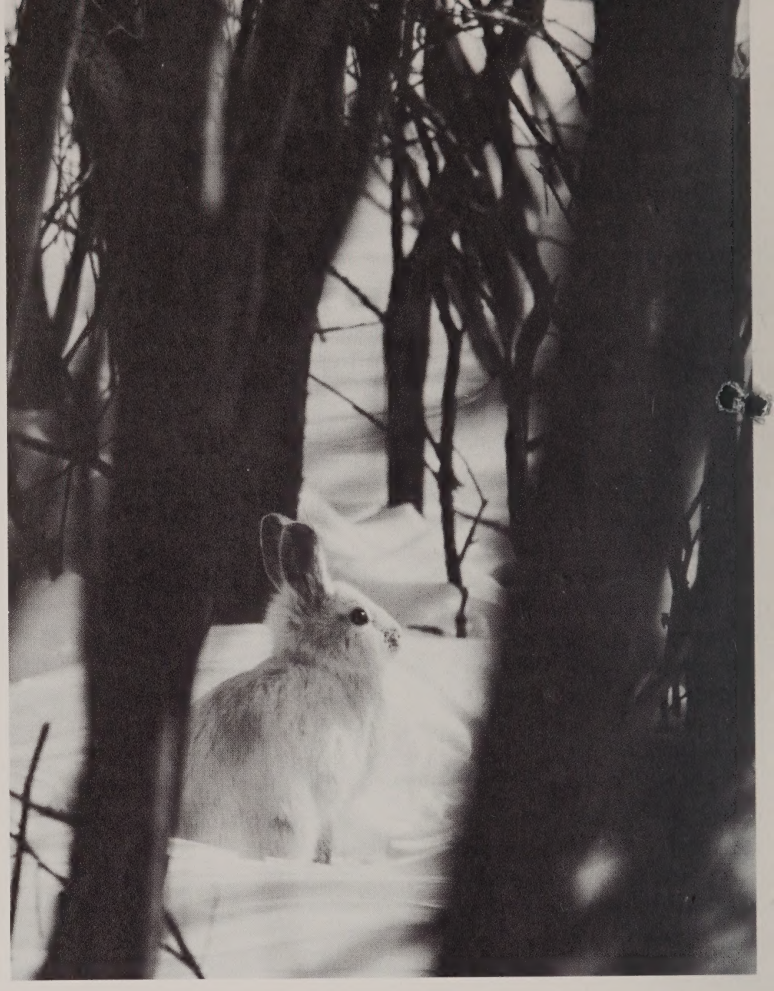
Outnumbering their predators is sometimes a conspicuous adaptation of prey animals. This was the key to survival for the now-extinct passenger pigeon, even though it laid only one egg a year. The huge flocks settled in and vastly overloaded many square miles of forest. They did their nesting all at once and got out before the predators could concentrate. In Africa, the migrating herds of wildebeest do something similar. They move into an area, have their young over a short period, and then are gone. Predators take a toll, but it is small compared to the great numbers of wildebeest.

Another kind of predator-prey relationship is illustrated by the regular cycling in numbers (about every 10 years) of hare populations in the northern hemisphere. Predators were suspected as a cause of the cycles, but they seem

to have been exonerated. They are indeed involved, especially the lynx, which preys as a specialist on the snowshoe hare. As hare numbers double and redouble, the lynx prospers and multiplies accordingly. On the other hand, when disaster strikes and the hare population crashes, the lynx (with a short delay) declines drastically. Both red and arctic foxes also show ups and downs in response to major changes in the numbers of hares, lemmings, and voles on which they feed.

Similarly, snowy owls produce more young and become plentiful in a period of small-rodent abundance in the Arctic. Charles Elton, David Lack, and other biologists extensively documented the increase in reproductive rate by many kinds of predatory birds when there is a glut of food, and correspondingly the reduction in productivity and numbers when prey becomes scarce.

In short, there is much evidence that small animals frequently determine the numbers of predators that depend on them for a food supply.



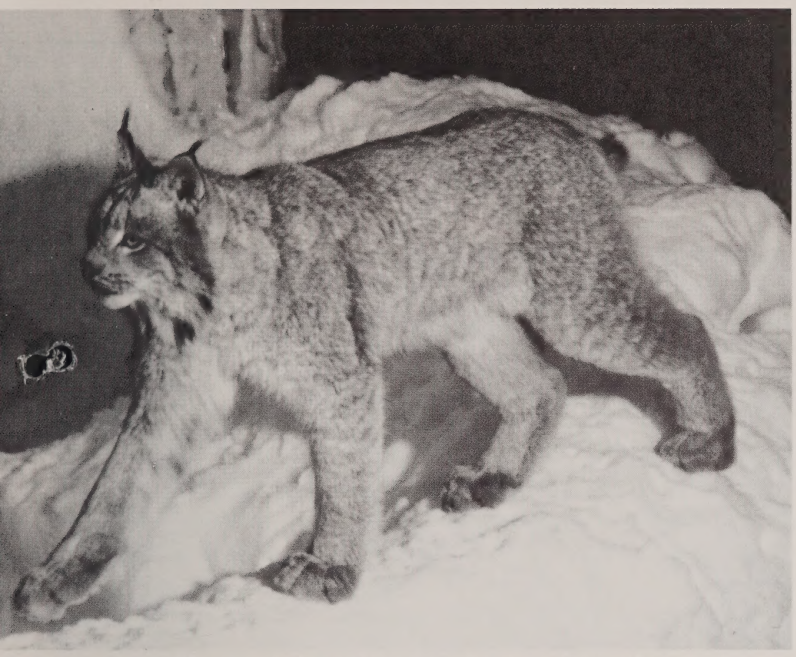
Habitat Conditions and Predator-Prey Relations

In decades following the dry '30s, investigators in the western U.S. carried out significant studies of range rodents and rabbits, including the effects of predation. Notably consistent was their finding that plant succession relative to grazing was a key factor in determining animal population levels. Small herb-eating creatures (e.g. woodrats, pocket gophers, ground squirrels, jackrabbits) reached high densities most commonly on overgrazed ranges, where perennial grasses had largely been replaced by annual grasses, weeds, and shrubs. These early stages in grassland successions produced "animal weeds," a food resource on which coyotes and birds of prey built up their numbers.

Increases in the predators did not appear to depress, correspondingly, the year-to-year populations of their food species, especially not to desirable economic levels. In his monograph on the prairie dog, Carl Koford summed up the situation: "If current predation theory is sound, generalized predators [those that prey on various species] could not be expected to hold the numbers of prey below environmental capacity. Nevertheless, through density-dependent effects [i.e., meat-eaters hunt best when prey numbers are high], predators should be able to lower the peaks of population increases and hinder the spread of dog towns."

The concept that habitat conditions tend to protect a large or small segment of the prey population against predation had emerged elsewhere. Paul Errington found that Wisconsin quail wintered well where food, cover, and weather favored them. Below a fairly predictable "threshold of vulnerability" the birds were relatively secure in a given area in ordinary winters. However, in a hard winter, the thresholds dropped, and by spring, horned owls and other predators had reduced the quail to an exceptionally low level.

Errington also did many years of research on muskrats and mink in Iowa marshes. He found that *uncrowded healthy* muskrats in a favorable habitat were seldom killed. The mink lived by a routine weeding-out of incapacitated or disadvantaged muskrats. But with the spread of disease, or with the drying-out or flooding



A regular cycling in numbers of the snowshoe hare (left) reflects itself in population fluctuations among lynxes (above), which prey as specialists on this long-eared mammal.

of marshes, predator-prey relationships changed. With the decline in carrying capacity (the maximum number of individuals that a habitat can support), a population "surplus" became available to the mink. The predation rate increased, muskrats in any state of health were taken, and wasteful feeding practices were in evidence.

Predation does not function independently. It is characteristically linked to other mortality factors and environmental influences, all of which interact to determine the numbers of prey.

Vegetation and Prey Populations

The basic population control among hoofed animals of the world is food supply. Even more basic, the condition and use of vegetation depend on weather. This relationship is striking on semi-arid grasslands and savannas of Africa, where periods of abundant rainfall or devastating drought bring major fluctuations in animal numbers. Among a diversity of specialized grazers and browsers—antelope of various kinds, zebras, giraffes, buffalo, warthogs—reproductive success or failure is the most direct response to changing conditions on the range.

The large predators are specialized to make primary use of certain prey. Hyenas and lions are especially effective on wildebeest and zebra, cheetah and wild dog on gazelles, leopard on the smaller species of borderline habitats and wooded areas. Feeding on young animals of any kind is to be expected according to their availability. Selective killing of malnourished or diseased adults is common practice as well. However, nearly all of the many recent investigators of these African problems have found that, as can best be judged, healthy adult prey animals also are commonly taken. This emphasizes again that healthy animals, depending on their numbers and conditions of their habitats, can become vulnerable to predators in many situations.

The extent to which predation limits the numbers of herbivores can differ widely from one area to another and from one time period to another. The classically complex African wildlife communities have become intricately adjusted for efficient use of the climate-controlled vegetation. The fact that they have persisted in approximately the present configurations over some millions of years attests that the feeders and the fed-upons have a relationship that works to their mutual advantage.

The annual overproduction in new generations, typical of all plant-eating animals, is the main support of the carnivores. Selective feeding on a part of this "crop" of plant-eaters is a kind of quality control beneficial to the prey. This natural function directs evolution along the lines of stock improvement and survival. It also calls to question widespread attempts to manage big game only with the gun. Could anyone but a wolf cull a deer herd as it should be done? It probably is true that we cannot preserve a prey species in the absence of its native enemies.

In the broadest sense, then, we can regard the predators as conservationists. The outlook would be better for our world and for us if we could say as much for ourselves.

A Professor of Wildlife Ecology at Purdue University, **Dr. Durward L. Allen** is the author of five books and over 100 feature articles in such national magazines as *National Geographic, Audubon Magazine, National Wildlife, Sports Illustrated,* and *Field and Stream.* His most recent work, *Wolves of Minong,* published by Houghton Mifflin Co. (1979), has been praised as "a beautifully written study of predator-prey relations that will take its place as a classic in wildlife literature." Dr. Allen is recognized as one of the nation's foremost wildlife scientists.

A CASE HISTORY:
Wolves and Moose on Isle Royale

In primitive North America the wolf was the dominant carnivore wherever there were large prey animals. Today, south of Canada, extensive control operations have nearly wiped it out. The only major wolf population (perhaps 1,000) is in northeastern Minnesota, though several small packs are doing well in Michigan's Isle Royale National Park.

During the past 50 years, outdoor publications have sometimes featured stories on overpopulated deer, elk, or even moose. In considering such problems, it must be remembered that we are dealing with incomplete wildlife communities. Deer, in particular, showed spectacular increases where lumbering and fires destroyed climax forests and induced extensive brushlands. In winters of deep snow the animals concentrated into lowland "yards" where they browsed the vegetation clean and where thousands of them died.

After mid-century, second-growth forests were maturing; ground vegetation was shaded out and deer declined. Many hunters thought coyotes were killing off the deer or that herds had been reduced by doe shooting. A pertinent question: Could wolves in their primitive numbers have held the deer in check, preventing much of the range damage and winter loss?

The results of field investigations in the 1960's and '70's—which were carried out in Alaska, Canada, Minnesota, and Michigan's Isle Royale—suggest that such relationships are indeed valid. However, protected wilderness areas where the wolf and its prey can be studied without the complications of human disturbance are rare. Isle Royale, a 210-square-mile island in Lake Superior, is nearly unique in this respect. There, 20 years of research have helped to fill in a picture of primitive relationships for the wolf and its largest antlered prey, the moose.

The fish-shaped island lies 15 to 18 miles from the Ontario shore. It was colonized by a few moose (no doubt by swimming) about 1910. In a pristine range and with no check on their increase, moose numbers probably reached 2 to 3 thousand by the late 1920's. By that time they had practically destroyed the browse of the forest understory. With food nearly gone, the herd largely died off in the early '30's. Possibly several hundred were left when a major fire hit the island in a year of drought, 1936.

The '40's brought normal rainfall, a greening in the big burn, new brushstage forests on a quarter of the island. Amid food abundance, moose were on the increase again. The situation recalled the overpopulations of protected elk in several western parks. Was this to be the future of Isle Royale, a fluctuating moose herd skimping along on an impoverished range? It seemed so, but important news came after the winter of 1949. A pack of wolves had crossed the ice, and moose were being killed. Now what?

That was the open question as we started our Purdue University wolf research in 1958. David Mech was the first of six graduate students who would carry the burden of the work. In 1980 it is still going on, with Rolf Peterson directing it from Michigan Technological University. After thousands of miles of summer hiking, hundreds of hours of winter observation from a light plane, and the examination of more than 1,500 moose remains—often only a few bones—what are the most pertinent findings?

For nine years wolf numbers averaged about 24. In seven of these years there was only one breeding pack, usually 15 or 16

Gray wolf, Isle Royale

by Durward L. Allen

A moose cow and her calf cross Washington Creek, Isle Royale

animals, plus a few loners and groups of two to four. It appears that Isle Royale fell into the usual pattern for maximum wolf populations, about one animal per 10 square miles.

In summer, wolves fed on moose and beaver. In winter they fed on moose. Their feeding was highly selective. A quarter of the winter kill was calves; of the remainder nearly all were over five years old. The average adult moose killed was 9 to 10 years old, and many older individuals showed jaw infections or other pathology. The pack of 15 cleaned up a 700-pound moose in three days.

With few exceptions, moose in the three-to-five-year-old age class were invulnerable to predation. Only one moose was killed for every 12 brought to bay or severely "tested" by the big pack.

In the first decade of the work, conditions and relationships were remarkably stable. But moose were increasing, to a high of about 1,100 in 1969. Beavers doubled in number, to about 2,000 in the early '70's. We had noted that in winters with about a foot of snow on the ground, moose were widely distributed over the island. In years of average snow, 25 to 30 inches, they concentrated in lowland conifers. The total population of wolves was below 20 for three years beginning in 1968.

The winter of 1969 brought deep snow across the continent from the lake states north. On Isle Royale we had 44 inches in the open level areas. This introduced a period when, in three out of four years, snow depth was three feet or more. During these winters the highest parts of the island were nearly devoid of tracks. Moose concentrated in the lowland conifers along shorelines more than ever before. But the wolves also traveled on the firmer snow, and the predation rate increased. The winter kill doubled, half of it consisting of malnourished calves. For the first time, carcasses were not being cleaned up; only the best parts were taken. Another new development: wolves were killing the two-, three-, and four-year-old moose. Bone studies showed that calves borne by cows after a deep-snow winter, or yearlings that had survived such a winter as calves, were delayed in reaching maturity. They did not develop normally, and their weakness was detected by the wolves.

In this three- to four-year period of abundant moisture the wolves greatly increased their summer feeding on beavers, and they became more successful at rearing litters. To our great surprise, in 1972 there were two breeding packs. In subsequent years two more were added. By 1975 Isle Royale supported over 40 wolves—more than we had ever imagined possible. Social tensions and fighting accounted for four dead wolves that we knew about. Beavers declined in the '70's, and the moose herd was cut to 800 or below. Calf survival was the lowest yet.

The Isle Royale record suggests an age-old pattern of wolves acting in concert with environmental extremes to dampen excessive increases of prey and hold numbers below levels that would destroy the food supply. Wolves are now beyond any density that can be maintained, and the pendulum must swing back again. The 1936 burn is maturing, and in another drought period lightning fires will burn away old growth and rejuvenate the range for more moose and beaver, and more generations of wolves.

Lands protected by The Nature Conservancy provide habitat for a variety of predators—from tiny insect-eaters to the larger carnivores. Because of the close interaction between prey and predator species in a given environment, the endangerment of either can have serious consequences for the entire ecosystem. A sampling of Conservancy projects securing habitat for endangered predators appears below.

Endangered Predators

Twin Culvert Cave
(Gray bat)

Virginia Coast Reserve
(Peregrine falcon)

Carrot Island/Bird Shoal
(Brown pelican)

Charley Owl Cave
(Indiana bat)

Green Swamp
(Eastern cougar)

Santee Coastal Reserve
(Alligator)

Pascagoula Hardwood Lands
(Bald eagle)

McFaddin Marsh
(Red wolf)

Crocodile Preserve
(Crocodile)

LAST OF THE DINOSAURS

by Paul S. Townsend and Anne M. Byers

They were worshipped and pampered by the ancient Egyptians, who placed delectable foods in their open mouths and adorned their legs with gold. When they died, the Egyptians embalmed their bodies and placed them in sacred tombs. Even a city was built in honor of one of their kind. It was called Crocodilopolis.

Today most of the 21 remaining members of the crocodile family are not faring so well. Despite the fact that they have been around for almost 200 million years, even survived the ice ages, species of the ancient order Crocodilia are disappearing at alarming rates. While the alligator appears to be one of the few crocodilians out of trouble, its saltwater cousin, the American crocodile (*Crocodylus acutus*), is barely surviving.

Crocodiles were once abundant in most countries bordering the West Indies, and many existed in southern Florida as well. As a matter of fact, 50 or so years ago, they were plentiful along the mangrove-covered sandbars that are now Miami Beach and ranged as far north as Palm Beach County. But unrestricted hunting in the 1950's and 1960's, and extensive land development in the '60's and '70's, especially in the Florida Keys, have placed the reptile on the list of officially endangered species. An additional contributing factor is that crocodiles are sometimes killed on highways —about two a year on Key Largo. (Although croc-hunting has been illegal for quite some time, only a year ago an 8-foot male was found shot to death. The carcass disappeared before wildlife biologists could return to collect it.) The American crocodile is now primarily limited to shores and islands of northeastern Florida Bay, in particular to the Everglades National Park and to northern Key Largo.

Given crocodile rarity and shyness, as well as the inaccessibility of their steamy, swampy homes, exact population numbers are elusive. Paul Moler, wildlife biologist with the Florida Game and Freshwater Fish Commission, estimates that there are between 200 and 400 crocs in the Florida Bay, Barnes Sound, and Card Sound areas. Of these numbers, only about 21 are nesting females.

Crocodiles are among the oldest living reptiles, and in some respects the most advanced. Their brains are more complex than those of other reptiles, so they learn quickly. Crocs have four-chambered hearts, almost as advanced as those of birds and mammals. They also have socketed teeth, another mammalian feature. All of these traits have enabled the crocodile to survive—until the present time. Crocs have made themselves at home on land and in the water; they inhabit salt-water bays and brackish estuaries, coastal mangrove swamps and sandbars. Powerful swimmers, they occasionally embark on trips into the open sea. In fact, in October 1978, a lone, 8½-foot crocodile was spotted swimming northward offshore from Hollywood Beach and Fort Lauderdale, almost reaching land that used to be part of its original range.

Until little more than a hundred years ago, no one knew there was an American crocodile; the croc had always been wrongly identified as an alligator. Actually, the two are different in both physical appearance and in choice of habitat.

Unlike the broader-faced alligator, the snout of the American crocodile is slender and moderately tapered, the head more triangular. Its reputedly evil, leering grin is mostly due to the position of its fourth eyetooth, which is always revealed when the croc's mouth is closed. As a matter of fact, it is this large fourth tooth in the lower jaw that differentiates crocodiles from the other crocodilians —alligators, caimans, and gavials (or gharials). Fitting into a notch in the upper bony jaw, the croc's 1-inch eyetooth gleams ominously and whitely on either side of the reptile's jaw. Actually, the fifth lower tooth is stronger than the larger eyetooth, interlocking with the teeth above to secure prey. A crocodile's teeth are fewer in number but larger than an alligator's and regenerate as needed throughout most of a croc's life.

A crocodile's muscular, flat, thick tongue is anchored to the floor of the mouth by its whole undersurface, allowing the tongue to move up and down slightly, but not to protrude. Sensitive projections of touch and taste cover its entire surface. When the croc is feeding underwater—with its nostrils and ears closed—a flap at the back of the tongue acts as a valve, so that the animal can swallow without water entering its lungs.

Like all crocodilians, crocodiles also possess a well-developed bony palate, a structure that runs from the nostrils to the back of the skull, forming an air passage. Since the crocodile has no lips and, therefore, cannot keep water out of its mouth, this adaptation—along with the "tongue valve"—permits the croc to breathe while almost totally submerged. The reptile glides silently along, with only its nostrils, eyes, and top of its head visible above water, its powerful tail undulating slowly back and forth, side to side.

When it comes to l'amour, crocodiles may go to great lengths to find true love. Courtship is prolonged and complex and has been observed to last as long as 4 weeks. After much display, which involves thrashing about in the water (head slapping) and snorting, the male croc climbs over the female's body, and copulation takes place under or in the water.

A female croc lays anywhere between 20 and 80 eggs, but only a small number have any hope of surviving. Natural predators, such as raccoons and skunks—which used to be nature's instruments of population control—are taking a toll on both eggs and hatchlings.

Croc eggs are most commonly laid inside a large nest mound, usually 12 feet in diameter and 2 feet high. Using nearby sand, marl, mud, or peat, the female crocodile may spend up to 4 weeks building her mound. When it is completed, the mother-to-be climbs atop the pile, digs a 10- to 12-inch cavity inside the nest mound, then drops her eggs into the hole and covers them up. (Occasionally crocs dig only nesting cavities in the ground without constructing mounds.)

While the eggs incubate for a period of three months, the mother keeps watch from a distance. However, at night, for reasons not entirely known, she will lie with her snout across the nest. When she begins hearing her 10-inch babies emerging, she uncovers the hatchlings and helps break open the eggs, then picks the youngsters up in her massive, bone-crushing jaws, and carries them gently to the water's edge. No one knows for sure if American crocodile mothers remain with their babies after birth as do alligators and some other crocodilians.

Initially, the diet of very young crocs consists of small fish, insects, and other tiny organisms. As master predators, adult crocs are opportunistic feeders, eating anything they can handle—fish, birds, turtles, crabs, small mammals. Current research on the American crocodile is not yet conclusive enough to reveal the animal's *exact* diet, but studies of other crocodilians show that most of the finfish taken are not those favored by sport

fishermen. In fact, a Louisiana study revealed that in areas where alligator populations were reduced, the rough fish, such as mudfish and bass-eating gar, increased. At the same time, the fisheries declined drastically.

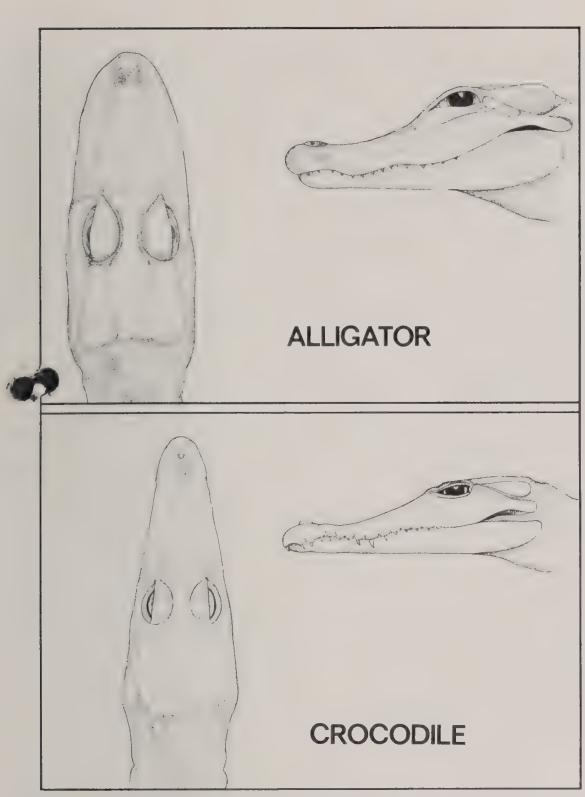
American crocs grow very rapidly during their first few months—thereafter at the rate of about a foot a year, achieving an average length of 11 feet, 8 inches. Lengths up to 15 feet have been reported. A croc's life span is 12 to 30 years. While baby alligators sport bright black scutes (scales) and yellow bellies, a croc hatchling's coloring is more subdued—olive-brown scutes and an ivory stomach.

Laboratory studies have shown that young American crocodiles can remain in full strength saltwater for only a few days, whereas an adult can exist in seawater for much longer periods. Consequently, brackish water may be preferred crocodile habitat. This mixture of fresh and saline water is created in northeastern Florida Bay, as well as around the Upper Keys, by the shallow, persistent flow of freshwater from Lake Okeechobee into the bay.

In the Everglades National Park, which borders Florida Bay, the crocodiles excavate burrows in the sand or mud banks of the park's rivers and streams. Den entrances are sometimes totally under water or half submerged, and the lairs penetrate the banks to a depth of from 12 to almost 30 feet. A croc widens and deepens its den by whipping its tail back and forth. Hidden amid and beneath the vegetation, the burrows provide warm retreats when the reptile's body temperature drops. Unlike mammals, crocodiles cannot regulate their body temperatures and are very sensitive to cold —more so than alligators, which most frequently are found in temperate and subtropical climates. Consequently, the tropical extreme tip of southern Florida is the only area in the U.S. providing optimum habitat for crocodiles. Preserving this environment is the key to saving the croc.

Two research projects were begun to help the American crocodile, one by the National Park Service in the Everglades National Park in fall 1977, the other by the Florida State Game and Freshwater Fish Commission, started in January 1978. The purpose of the Everglades study is to determine the status of the crocodile population in the park—whether it is increasing or decreasing or remaining stable. This is done by using radio collars to monitor the movements of both young

After three months of incubation in a mound nest, American crocodile eggs hatch, and the tiny baby crocs emerge. It is unknown whether crocodile mothers remain with their young after birth as alligators do.



Key physiognomic differences between the alligator and the crocodile: the former's snout is blunt and rounded, the latter's narrow and pointed with protruding teeth (especially the fourth on the lower jaw). Illustration by Don Martin.

and adult crocs. If the population is decreasing, it may well be caused by a condition that the Park Service can correct. For example, if increased salinity in Florida Bay is adversely affecting baby crocs—a factor that is being examined by studying the environments and physiology of juvenile crocodiles—it might be corrected by proper water management.

Jim Kushlan, Director of the Everglades study, explained that saving an endangered animal can be attempted in one of two ways: by repairing an unstable ecosystem or by helping the creature itself. "But ideally you should combine both techniques," he said. "In Florida Bay, we have a chance to do just that—to manage the ecosystem for the croc's survival, and to protect the animal by creating a crocodile refuge."

The other research project, being conducted by the Florida Game and Freshwater Fish Commission with substantial funding from the Office of Endangered Species, U.S. Fish and Wildlife Service, is determining the status and distribution of crocodiles outside the Everglades National Park. Led by wildlife biologist Paul Moler, researchers are focusing on a large area on northern Key Largo, which was identified by the American Crocodile Recovery Team as ideal croc habitat. (The Recovery Team is comprised of representatives from the National Park Service, Florida Game and Freshwater Fish Commission, Fish and Wildlife Service, and the National Audubon Society.) By compiling information on the locations and movements of Key Largo crocodiles, Moler can identify which areas of land on the island should be included in a proposed federal refuge. Containing around 6,000 acres, Crocodile Lake National Wildlife Refuge will fulfill the second half of Jim Kushlan's "equation" for saving the crocodile.

The first tract of land for the refuge has already been acquired. The Nature Conservancy purchased an 18-acre area now called the Crocodile Preserve. The property, which had to be bought quickly to prevent development into a fish farm, serves as vital buffer for the adjacent Basin Hills area where Paul Moler found six active crocodile nests in 1978. Land around nesting areas must be preserved to protect the endangered crocodilians.

So far the results of the Everglades Park study and the research being done by the Florida Game and Freshwater Fish Commission have caused both Jim Kushlan and Paul Moler to be much more optimistic about saving the American crocodile than they were two years ago, when their separate though cooperative projects were begun. Kushlan said, "In addition to the fact that we're finding more nests, there are also more eggs hatching—201 in 1979, a 14 percent increase over 1978." Nest predation by raccoons has not been as great as first expected either. "But the most important reason for being hopeful," added Moler, "is that we are finding more young animals—both juveniles and intermediate-sized crocs—which means that surviving hatchlings are joining the breeding population. This indicates that the crocodiles of Florida Bay are a successfully productive group."

The line of descendancy of the American crocodile goes all the way back to the Archosauria—the large group of reptiles that included the awe-inspiring dinosaurs. But despite their ancient origins, their existence long before mammals—not to mention humans—crocodiles are disappearing from the planet. Perhaps we could stand to learn something from the Egyptians, at least by creating a 20th century Crocodilopolis . . . but only for real, *live* crocs.

Educated in biology, **Paul S. Townsend** spent several years in the Caribbean doing research. For the past seven years he has been primarily interested in studying and observing the endangered American crocodile in the Florida Everglades. **Anne M. Byers** is Associate Editor of the *News*.

Winged Fingers, Seeing Ears...

by Virginia M. Tipton

with Alan R. Tipton

One morning, I received a frantic call from the rector of a local church. "There's a bat in my son's room—what can I do?" "Well, just open the window and let it fly out," I told him. But a lengthy conversation made it clear that nothing would induce him to go back into that closed room to open the window. So that afternoon, I went to his home, carrying a pair of gloves and a cage. The rector immediately led me to his son's room, cautiously cracked the door open and peeked in. "It's hanging on a curtain," he said. I slipped into the room, quickly shutting the door behind me. The bat was asleep, clinging upside down to the folds of the curtain. With gloved hands, I gently and easily removed the lethargic bat and placed it in the cage. Before reopening the door, the rector had to be assured that the bat was really secured in the cage. Afterwards, he was amused and a little embarrassed; nonetheless, his reaction was indicative of the prevailing attitude toward bats.

Why do bats evoke such feelings of fear and repulsion? For most of recorded history, little was known of the creature's habits—they were seldom observed close at hand. This ignorance of bat biology and behavior led to groundless fears and misconceptions. Negative attitudes were reinforced as bats became central characters in tales of the supernatural and occult. Unfortunately, a bat's appearance does not improve its maligned reputation. Because of evolutionary adaptations for flying, feeding, and hearing, some are proud owners of huge ears, grotesque facial features, and shrill voices.

What actually is the truth about this creature that elicits such fear, that has a reputation for flying into one's hair and carrying rabies?

First, let's set the story straight about rabies. Bats can and do carry rabies; however, experts have estimated the frequency of the disease in bats at less than one percent, as compared to three to four percent in skunks and foxes.

Like all other mammals, bats give birth to live offspring, which subsist on their mother's milk. However, because of a series of remarkable adaptations, bats are the only mammals that have achieved true flight. A bat's wing is structured much like the human arm—it has an upper arm, a forearm, wrist, and hand. The fingers of the "hand" are greatly elongated and occupy most of the wing, allowing it to be intricately manipulated. The wing membrane itself is a thin, tough, and flexible double layer of skin. Small, thin bones

Gray bat

and a much reduced pelvis minimize weight for flight. Since these bones cannot support the entire weight of the bat in an upright position, it hangs upside down or lies on a flat surface on its belly. Consequently, the animal does not "leap" into flight, but rather "falls" into it.

Though commonly believed to be blind, all bats have functional eyes. Some of the larger species, called megabats, have big eyes that are specially adapted to enable the bats to gather food in dim light, such as at dusk. Their primary food sources are fruit, flower nectar, and pollen.

Another major group of bats, the microbats, have smaller eyes and rely more heavily on their ears for navigating. These species maneuver in the dark using an intricate sonar system. They emit high frequency sounds (ultrasonic pulses that we cannot hear) and interpret echoes as the sounds bounce off solid objects, thus enabling the animals to navigate around obstacles. Most of the "echo-locating" bats are small, prey solely on insects, and have large, oddly shaped ears, which are specifically designed to catch returning echoes.

Although the majority of bats live in the tropics, some of the microbats are adapted to more temperate areas, including parts of the United States. Most American bats are insectivorous, feeding on those insects that are active at night.

When foraging, an insectivorous bat uses its sonar system to locate prey. It catches the insect in flight, either in its mouth or by "scooping it up" in the wing or tail membrane and then transferring the bug to its mouth. A single bat may eat one quarter to one third of its body weight in insects each night. Since many of the insects are agricultural pests, the bat acts as a "natural insecticide," eliminating the need to use damaging or potentially harmful chemicals.

Unfortunately, insectivorous bats are faced with a disappearing food source during the winter—a problem they have solved in two ways. They either migrate to the southernmost states and Mexico where insects can still be found, or they hibernate until their food source is once again plentiful and reliable.

Most American bat species hibernate—although many will migrate a little further south to do so—and the hibernating period varies in length depending on the severity of the winter. Roosting sites include trees—in hollows or under the bark—and some caves. But few caverns are suitable because hibernating bats require precise combinations of temperature and humidity.

Before winter, the animals accumulate and store fat, which supplies them with a food reserve during hibernation. While dormant, a bat's body temperature drops close to that of its surroundings (but always just above freezing or the animals will die); heart and breathing rates slow drastically. Overall reduction in metabolic activity allows them to survive on the relatively small amount of stored food. This is a very critical period for the small predators. If disturbed during hibernation, a bat is totally helpless for 15 to 30 minutes—the time it needs to arouse itself sufficiently to fly. Moreover, if "awakened" too many times while in this torpid condition, it will use all of its food supply and die before spring arrives.

Bats emerge from hibernation when insects are again available. Then, in the early summer, females give birth generally to one offspring. Cave-dwelling bats occupy "nursery roosts" where they raise and care for their young, though some species, such as the big brown bats, prefer attics. Like hibernation, nursing time is a critical period. Mother bats must leave the roosts at night to forage. Totally helpless and unable to fly, the young are left hanging—literally—until the females return. Mothers locate their offspring by smell, sound, and memory.

Unappreciated Allies

Bats are of immense and unrecognized benefit to the environment and, in turn, to the human spe-

cies. Most bats are insectivorous, devouring a total of millions of tons of insects annually. (In Texas, Mexican free-tailed bats are reported to consume 20,000 tons of insects each year.) Caves inhabited by bats contain vast amounts of their waste, or guano, which supports many other cavern-dwelling species and is a nitrogen-rich fertilizer. Furthermore, by studying the highly specialized creature's unique sonar and echo-locating systems, we may eventually possess the knowledge needed for developing similar systems to enable blind persons to navigate around obstacles with "seeing ears."

Although most bats are not harmful to humans, the inverse is not true. Like many other forms of life adversely affected by the haphazard growth and ignorance of the human world, bats are declining rapidly. Reductions of U.S. populations were reported as early as 1952. The Mexican free-tailed bat (*Tadarida brasiliensis mexicana*), a "non-endangered" species, provides a striking example of dwindling numbers. In 1936 the population at Carlsbad Caverns in New Mexico was estimated at over 8,000,000. It dropped to just over 3,000,000 in 1956, and was down to about 250,000 by 1962.

Several bat species have been declared endangered species by the U.S. Fish and Wildlife Serv-

Top: a cave ceiling hung with Indiana bats; above: a close-up of the same—its "seeing ears" prominent above its small facial features.

ice. The Indiana bat (*Myotis sodalis*) has been on the Federal Endangered Species list since 1966. The gray bat (*Myotis grisescens*) is also listed. On November 30, 1979, two big-eared bats, *Plecotus townsendii virginianus* and *Plecotus townsendii ingens,* were officially classified as endangered. All of these species are cave-dwellers.

There were two major reasons for listing them as endangered. One was the documented observations of alarming reductions in total numbers, or the disappearance of *entire* populations from certain previously used caves. The other reason is that the hibernating and nursery roosts required by the four bat species are extremely scarce. It has been estimated that 90 to 95 percent of the total hibernating gray bat population, about 2,000,000, is now restricted to only five caves. Over the past 20 years, colonies in excess of 100,000 individuals have vanished from five other caverns. About the same percentage of the Indiana bat population—numbering around 500,000—hibernates in only 13 caves. This species has virtually disappeared from the northeastern U.S. Fewer than 5,000 of the two big-eared bats remain, inhabiting only a few caves. When a species' population is concentrated in so small an area, a local catastrophe such as flooding could greatly affect its size.

Evidence is still being accumulated, but virtually every bat biologist has observed or strongly suspects a high correlation between human activities and the continued decline of our four endangered bats. Many caves, having been opened to the public as tourist attractions, used heavily by spelunkers, or surrounded by urban development, are no longer suitable habitat for bats.

In some cases bat populations have been exterminated deliberately. In one report, an estimated 10,000 bats were killed in a single cave. Three boys tore hibernating bats from the ceiling, stoned and trampled them, or let them fall into a stream where they drowned. Summer nursing colonies of gray bats are particularly sensitive to human disruption. Merely shining a light on them will cause mothers to drop their young, resulting in high infant mortality. Also, entire maternity colonies of other species have disappeared from disturbed caves, or have significantly reduced their numbers.

Even the activities of bat biologists who enter caves trying to gather information on the status of bat populations are probably detrimental to hibernating or nursing species. Consequently, many researchers have curtailed certain methods, such as banding, or have refined others to disturb the bats as little as possible.

Like many other disappearing species, insectivorous bats—both endangered and not—suffer from the use of pesticides. Organochlorine pesticides are a particular threat. Bats apparently eat insects that have survived DDT poisoning. Unfortunately, the toxic substance accumulates in the bats' bodies, eventually reaching lethal doses. Studies have revealed that bats are approximately 10 times more sensitive to DDT than other laboratory animals. The large decline of the Carlsbad population has been attributed to this insecticide. Despite the ban on some of the organochlorine compounds, such as DDT, bats are still succumbing to the chemicals that remain in the environment. Some of the newer organophosphate and carbamate pesticides may be killing the species as well.

Clearly, protective measures must be initiated to preserve America's flying mammals. Those species with endangered status are protected by law. The penalty for harming or harassing them is up to a year in prison or as much as $20,000 in fines. Under the Endangered Species Act, federal agencies are prohibited from any actions that might result in losing what has been designated as "critical habitat" for endangered bats; some states have passed similar legislation. In a few cases, an attempt has been made to protect caves by securing them behind gates and fences. Because many caverns are not on state or federal property but on privately owned land, government agencies and private organizations are attempting to protect those caves as well, by acquiring them or through other conservation methods. The Nature Conservancy, for example, has preserved four properties, two in Illinois, one in Ohio, and another in Oklahoma, which contain caves used by hibernating or nursing colonies of endangered gray and Indiana bats.

The public is encouraged to follow the example of the National Speleological Society, which instructs its members to avoid caves that harbor endangered species of bats or large numbers of any bat species during critical periods of hibernation and nursing. Education is the only way to counteract the ignorance that has developed over centuries. These remarkable creatures—our only winged mammals—are vital to the environment and deserve our respect.

Dr. Virginia M. Tipton and **Dr. Alan R. Tipton** coauthored our article on insectivorous bats. Virginia Tipton was trained in biospelology (cave biology) and teaches general biology, cell biology, and comparative animal physiology at Radford University, Virginia. An assistant professor at Virginia Polytechnic Institute and State University, Alan R. Tipton teaches wildlife population ecology and the relationship of the populations to their environment. Both authors are studying endangered bat species in Virginia through a grant from the state's Commission of Game and Inland Fisheries.

MASKED MUSTELID

by Conrad N. Hillman and James W. Carpenter

The black-footed ferret (*Mustela nigripes*) may be one of the most endangered mammals in North America, as well as one of the rarest animals in the world. First described by Audubon and Backman in 1851, it was not reported again for 25 years. The status of the ferret has generally remained a mystery—it has been seen only on rare occasions, and, therefore, its life history and ecological requirements are largely unknown.

Like the weasel, mink, skunk, and river otter, the black-footed ferret is a member of the mustelid family (Mustelidae). The only ferret native to North America, its distinguishing characteristics are a distinct black mask, black feet, and a black-tipped tail, which contrast with its tan to yellowish back and sides and lighter underparts. The mink-sized animal weighs between 1½ to 3 pounds; the male is usually larger than the female. Unlike some other members of the weasel family, its coat does not turn white in winter.

The black-footed ferret's nearest living relative is the Old World Siberian ferret or polecat (*Mustela eversmanni*), which occurs throughout vast areas of the Soviet Union and northern China, and is reported to be common in many localities. Some subspecies of the Siberian ferret closely resemble the black-foot in size, coloration, and habits. Another close relative, the European or fitch ferret (*Mustela putorius*) is often confused with the black-footed ferret. This European species was imported to the United States for rat control and hunting, and is now a common laboratory and pet store animal. It can be distinguished by its longer and more conspicuous guard hairs, a tail two-thirds or more black and slightly tapered, and a muzzle more pointed than that of the black-footed ferret. Although fitch ferrets usually have a mask and black feet, their coloration ranges from albino to very dark.

Dwindling Numbers and Habitat

The black-footed ferret has probably never been abundant. Only a few sightings were recorded, and many early naturalists considered the masked mustelids rare. The fact that ferrets were used in religious ceremonies by the Plains Indians—who valued scarce furs—also suggests rarity. Stuffed ferrets were used in medicine bundles, and ferret skins were made into tobacco pouches.

However, the fact that only a few early sightings of the ferrets were recorded could be related to two things other than rarity. First, the Great Plains region was thinly populated, so there were few observers. Second, black-footed ferrets are seldom

seen because of their secretive and nocturnal habits. They restrict their above-ground activity to nighttime and early morning periods. It is very likely, then, that the casual observer, farmer, or rancher would be unable to detect or to identify the animal. Records do indicate, however, that workers directly involved with early prairie dog control programs or on collecting assignments did see some ferrets. Sixteen specimens in the U.S. National Museum, housed in the Smithsonian Institution's Museum of Natural History, were collected from one county in Kansas during 1884 to 91, and 44 ferrets were reported taken in South Dakota between 1823 and '29.

The black-footed's original range corresponded closely to that of the prairie dog. Ferrets have been reported from the Great Plains region, extending from the Canadian prairie provinces south to the west Texas plains, and from east of the 100th meridian to the mountain basins of Utah and Arizona. Since the ferret's present range appears considerably reduced from its original occupied area, the animal's current distribution is uncertain. However, reported sightings from several locations suggest that remnant populations may still exist in South Dakota and neighboring states. Actually, many people believed that the black-footed ferret was extinct—until 1964, when it was "rediscovered" in South Dakota.

The decimation of ferret populations was probably a result of habitat destruction, prairie dog control programs, and agricultural land-use changes. Some ferrets have also been lost to trapping, shooting, highway killings, and attacks by domestic dogs.

Ferret Life History

Black-footed ferrets are nearly always associated with prairie dogs. Besides preying almost exclusively on prairie dogs, ferrets live in prairie dog towns, and raise their young in the rodents' burrows.

The relationship between ferret and prairie dog is unique. Although ferrets eat these large burrowing rodents, prairie dogs often seem barely concerned about a ferret's presence above-ground. In fact, rather than retreating, prairie dogs are often quite aggressive, chasing the masked predator across the town, even running alongside or jumping in front of it. The prairie dogs are probably doing nothing more than harassing the ferret; however, the rodents will retreat if the mustelid stops and defends itself.

Primarily nocturnal, a black-footed ferret is usually active two to three hours after sundown, and again in early morning before dawn. It hunts at night, possibly traveling throughout the prairie dog town. Often it will run from burrow to burrow, go below for several minutes, then reappear to dash to the next hole. When a ferret has descended a burrow, prairie dogs above-ground will often kick dirt into the opening, trying to plug the tunnel entrance. They frequently succeed. However, the ferret has little difficulty in later digging through the blocked passageway. After killing a prairie dog, always inside a burrow, the ferret may then carry the dead rodent to another den, possibly remaining with its meal for one or two days. Occasionally, the black and tan predators are active during early morning daylight. Then they most often enjoy basking in the sun on the edges of burrows, or peering out of tunnel entrances with only their masked faces visible.

The black-footed ferret is most commonly observed during late summer or early fall, especially as part of a family group. They are seen infrequently during other seasons; however, ferrets don't hiberate, but are less active during winter and spring months.

After breeding in March and early April, ferrets have a gestation period of 42 to 45 days. Litters of up to five young are born in a prairie dog burrow. At birth they resemble small mice—their eyes are tightly shut, and markings are not evident. The kits remain in the burrow until late June or early July when their mother begins bringing them above ground. At this time the young ferrets are one-half to three-fourths adult size.

In early summer, the kits most often occupy one burrow, although the mother may move them

Prairie dog towns are home to the black-footed ferret, which preys almost exclusively on the burrowing rodents.

to a new burrow where she has made a kill. They remain there for several days. As the season progresses, the mother places her offspring in separate burrows throughout the prairie dog town. At night she may go to each den occupied by her young, and the kits follow as she travels about the town. Adult male ferrets take no part in rearing the young. Observations of single animals suggest that males live like isolated bachelors, except during the breeding season.

By early September the young ferrets are no longer dependent on their mother. Then in late September or early October, most of them leave the prairie dog town. Where they go is uncertain, since there is little information on ferret movement and dispersal; however, black-footed ferrets have a tendency to disappear from towns, as well as to reoccupy prairie dog towns that were previously inhabited by ferrets.

Attempts at Captive Propagation

Fearing that wild populations of the black-footed ferret would not respond solely by protecting remaining animals and habitat, the U.S. Fish and Wildlife Service's Endangered Wildlife Research Program began a ferret captive propagation program. Its goal was to create a captive breeding stock of ferrets with which to repopulate more of the prairie dog towns within the mustelid's original range. Through comparative studies between 1968 and 1971 of the more common European ferret, techniques were refined for use in breeding captive black-footed ferrets. From 1971 to 1973, black-footeds were captured in South Dakota and transported to the Patuxent Wildlife Research Center in Maryland for breeding and scientific study.

Of the five ferrets used in the breeding program, two were females. Only one of the females was ever receptive to any of the males. In 1976, this female produced the first litter of black-footed ferrets ever born in captivity. Unfortunately four of the five young were stillborn, and the remaining kit died because its mother did not provide it with adequate care.

Since earlier studies had shown that European ferret females readily accept young from other ferrets, as well as from other species, the researchers decided to remove the kits immediately after the second birth in 1977 and to place them with a lactating European ferret. Two men observed the pregnant black-footed ferret from a "blind" for 5 days, 24 hours a day, until she produced four stillborn kits and one weak young. Although

Mustela nigripes *surveys his territory. The only ferret native to the New World, the highly endangered black-footed is a relative of the Old World Siberian ferret or polecat.*

the surviving kit was readily accepted by a lactating European ferret and also received intermittent medical care, it died two days later.

In view of the female's advancing age—about 12 years—and her history of stillborn litters, in 1978 it was decided to take the young by caesarian section, hoping that they might be saved. The female ferret was "bred" successfully, and her abdomen distended over the next six weeks. She was taken to the Research Center's veterinary hospital 42 days after breeding. Although the surgery was successful, the female did not contain any young—she had a *false* pregnancy, probably a reflection of her age. Once again, producing young black-footed ferrets in captivity had eluded the researchers.

It should be noted that the ferrets in the propagation program were all captured within a restricted area in South Dakota, where the possibility of obtaining closely related animals was likely. The disorders encountered in these animals—including diabetes mellitis, stillborn litters by one female, irregular heat cycles in the second female, cryptorchidism in one male, and cancer in all five ferrets—suggest inbreeding. These disorders may even reflect processes that are occurring in other small, isolated wild ferret populations. In other words, the species may be having difficulty surviving in the wild partly because of a decrease in genetic variability.

Although the program's five ferrets died, researchers are optimistic that captive propagation of black-footed ferrets using the techniques developed at the Patuxent Wildlife Research Center may still succeed, if—and when—more animals can be found that are younger and genetically unrelated.

Beginning Protection Methods

Since finding and observing black-footed ferrets is not an easy task, little is known about the rare mustelid's current distribution, home range, or movements. Nevertheless, several surveys and studies have been done or are now going on to locate ferrets, in order to develop protection programs, particularly in areas scheduled for prairie dog control, or where other activities may jeopardize all the rodents or possible resident ferrets.

Some of the agencies involved in ferret research are the U.S. Fish and Wildlife Service, Bureau of Land Management, the Forest Service, various state game and fish or conservation departments, and private groups like the Audubon Society and The Nature Conservancy. The Wyoming Natural Heritage Program, a joint venture between the state's Department of Environmental Quality and the Conservancy, is currently collecting information on and mapping occurrences of black-footed ferrets in Wyoming. By inventorying the state for ferrets, protection and management programs can be developed for areas where the animals are known or believed to survive.

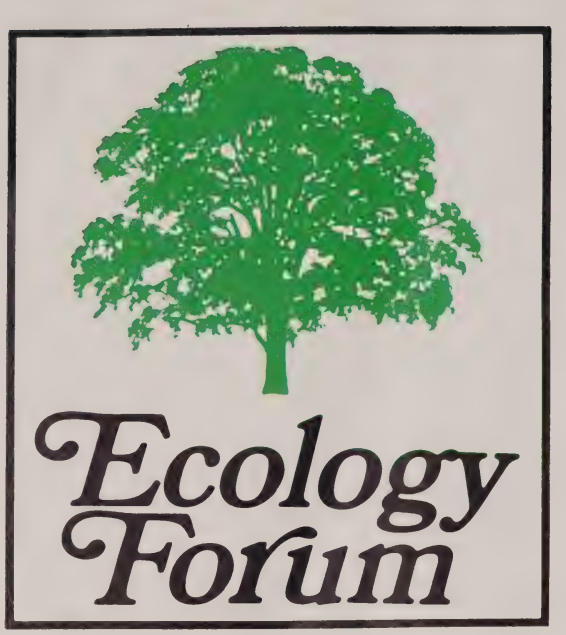
Searching for ferrets entails recognizing certain characteristic signs. For instance, when black-footeds dig in prairie dog burrows, they back out of the tunnel with the dirt held against their chests, dragging it further from the entrance with each trip. This creates a long trench-like accumulation of loose dirt. Although these narrow dirt piles are one of the best indicators of ferret activity, prairie dogs often destroy the trenches within a few hours after sunrise. Numerous plugged burrows may also signify the presence of ferrets underground; but prairie dogs are known to plug tunnels as defense against other mustelid predators, such as weasels. Occasionally, the rodents will stopper burrow entrances for no discernible reason.

Researchers are also attempting to improve and refine ferret detection methods. For instance, domestic dogs have been trained to detect a ferret's scent. Other methods for monitoring movement of ferrets and determining their habitat needs are being developed as well.

Toxicants, such as zinc phosphide, that don't cause secondary poisoning are now available for prairie dog control. (That is, a ferret can eat a poisoned prairie dog and not, in turn, succumb to the poison.) Also, ferret surveys are being conducted in many areas before control programs are begun. Moreover, the Fish and Wildlife Service has been granted easements enabling it to protect areas where black-footeds have been known to occur in recent years. Many federal and state agencies now are developing management plans that will leave adequate numbers of prairie dog towns as ferret habitat.

It is hoped that the new detection techniques and various surveys will provide additional information on the status and distribution of black-footed ferrets. The sooner we can locate the rare mustelids, the more rapidly we can attempt to bring them back from the brink of extinction.

A biologist with the Endangered Wildlife Research Program of the U.S. Fish and Wildlife Service, **Conrad Hillman** has been conducting field studies of the black-footed ferret in South Dakota since the late 1960's. He is the recognized authority on the masked mustelid. **Dr. James Carpenter** is the research veterinarian for the Endangered Wildlife Research Program, as well as one of the few wildlife vets in the country. He has worked at the Patuxent Wildlife Research Center since 1974 and is one of several professionals supervising the Center's endangered species captive propagation program.



No. 36
by Steven C. Buttrick
Plant Ecologist

PREDATORY PLANTS

*The "snake tree" is described in a newspaper paragraph as found on an outlying spur of the Sierra Madre, in Mexico. It has sensitive branches of a slimy, snaky appearance, and when a bird alights on them incautiously, it is seized, drawn down in the tree and lost to sight. Soon afterwards it falls, flattened out, to the ground, where bones and feathers, no doubt of former captures, cover the earth.**

If it is incredible that the story of the "snake tree" should catch on, it is at least as incredible that about 500 species of vascular plants and over 50 species of fungi are carnivores. There are six genera and over 45 species of carnivorous plants in North America, but their prey ranges from single-celled amoebae to flies and other insects—so there's no need to stop taking walks in the woods. Nonetheless, it seems a stunning reversal of the natural order: plants eating animals. What makes it happen?

All organisms have two basic nutritional needs: one for sugars to produce chemical energy, and another for elements such as calcium, iron, sulfur, nitrogen, and magnesium. Of these, nitrogen has special importance as a key component of all proteins. While plants use their ability to mix sunlight, carbon dioxide, and water to produce their own sugars, animals must eat plants or plant products to get theirs. And whereas plants can obtain needed minerals from the soil through their roots, animals must get these second-hand by eating plants or other animals.

In areas where the soil is nutrient poor—such as acid bogs, marshes, and certain wet savannas—botanical diversity is low, since very few plants can tolerate impoverished levels of essential nutrients, especially nitrogen. But some plant species have adapted to these habitats—and they have done so by evolving the ability to "eat." By trapping and digesting insects and other small organisms, carnivorous plants supplement their nutrient intake. Although all of these plants can live without "eating," they are larger, more robust, and longer-lived when their diets are supplemented by living organisms.

The carnivorous properties of plants reside solely in their leaves, which attract prey by the same means (color, nectar, odor) as their flowers attract pollinators. Once the prey reaches the leaf, it is entrapped. Predatory techniques differ from one plant species to another, but there are four major trap types: pitfall traps, flypaper traps, snap traps, and suction traps.

Pitfall traps are characteristic of the pitcher plants, the most common of which occur in the genus *Sarracenia,* found throughout eastern North America. Others include the California pitcher plant or cobra lily (*Darlingtonia californica*) and live only in northern California and along the Oregon coast. All pitcher plants are characterized by open-tipped tubular leaves, usually containing water. Insects, attracted by the color of the leaves and the nectar glands along their rims, venture into them only to slip on the slick inner walls and fall into the "pitcher." The prey is then reduced by digestive enzymes to a solution that can be absorbed through the walls of the leaves. Digestion in all carnivorous plants occurs externally this way, with the products being absorbed through the leaf. Bones of small frogs have been found within the pitchers of *Darlingtonia.*

The sundews (*Drosera*) and butterworts (*Pinguicula*) trap their prey by means of the flypaper method. Sundews have long-stalked, sticky red glands on their leaves. Small insects, attracted to the leaves, are hopelessly stuck. Digestive glands then start to secrete dissolving enzymes, and the plant "eats." The same is true for the butterworts, except that the glands are not noticeable, and the whole surface becomes sticky. Usually the edges of the leaves will slowly curl up around the prey. Both genera are common to acidic bogs and wet

*Prior, Sophia. "Carnivorous Plants and 'The Man-eating Tree'", *Chicago Museum of Natural History Botanical Leaflet,* no. 23 (1939), p. 20.

savannas on the east and west coasts. Because butterworts are easy to overlook when not in flower, less information is available on them than on other groups of predatory plants.

Snap traps are used by the familiar Venus' flytrap (*Dionaea muscipula*). This rare species is found in scattered locations in eastern North and South Carolina—and in flower shops and supermarkets across the nation. The plant's leaves have a jaw-like configuration—with two similar halves connected by a mid-rib. These halves snap shut with lightning speed when an unwary insect crawls inside and trips a series of trigger hairs. While large insects can push the "jaws" apart and escape, smaller ones become nutrients for the captor plants.

The action of suction traps in bladderworts (*Utricularia*) has been the most puzzling for scientists, partly because of the size of the trap (.5-3 mm), the speed of the trap action (1/460 of a second), and the fact that the whole process often takes place underwater. The trap is a small modified leaf called a bladder. When the trap is "set," the bladder contains no water, and the sides are concave; but if anything brushes against the hairs surrounding the veil of plant tissue that guards the trap's small entrance, it opens, water rushes into the bladder and carries the prey with it. Then the "trap door" or veil swings shut.

Much attention has been given to these remarkable and somewhat bizarre plant species, but another group of plant predators is often ignored. These are the predator fungi. Unlike the higher plants discussed thus far, fungi cannot produce their own sugars, so they are usually parasitic (living off live organisms) or saprophytic (living off dead organisms). However, there are over 50 species of fungi that actively capture live prey and then feed on the bodies while they are moribund or once they are dead. Such fungi are confined to two orders: the Moniliales, which includes *Aspergillus* and *Penicillium,* and the Zoopagales.

Unlike the carnivorous plants that merely supplement their diets with prey, many of these fungi require what they capture to survive. Their prey—rotifers, nematodes (eelworms), and protozoans (such as amoebae)—are captured by means of three methods: adhesive traps, non-constricting rings, and constricting rings. Adhesive traps capture the prey when fungal threads (hyphae) in sticky knobs or networks penetrate the prey's body and consume it. Nonconstricting rings catch nematodes when fungal threads form tiny loops through which the fatter nematode attempts to crawl. The most effective traps, however, are the constricting rings, in which the loop is larger and allows the nematode to pass halfway through—then contracts around it. Some fungi are so successful at capturing nematodes, which are agricultural pests, that researchers are determining the feasibility of introducing these fungi into farm lands.

While the predacious fungi enjoy substantial security because they are small and relatively unknown, the higher carnivorous plants are severely threatened throughout much of their North American range. Their odd appearance and even odder diets make them obvious objects for exploitation by many nurseries, florists, supermarkets, and biological supply houses. It is naive to believe that all the individuals offered in such "shops" are derived from cultivated stocks. Many are collected in the wild. The habitats of these plants often cover such small areas and have such limited distribution that entire populations can be lost through over-collection.

Habitat destruction is another major threat. The wet, open habitats where carnivorous plants thrive can easily be destroyed by artificial drainage, frequently undertaken to make the land more suitable for timber growth or peat mining. And even protected habitat can be destroyed through mismanagement. Over time, these wet savannas, bogs, and marshes dry out as organic matter accumulates, and shrubs and trees enter the picture—plants with which sensitive carnivorous species cannot compete. In the absence of human intervention, these habitats were often maintained by fire, which removed the woody competition.

The Nature Conservancy has already contributed greatly to safeguarding these living curiosities. Predatory plants are found on a number of preserves, such as the Roy E. Larsen Sandyland Sanctuary in Texas, Green Swamp in North Carolina, the Santee Coastal Reserve in South Carolina, and Boggs Lake in California. The preserves' progressive management policies, including prescribed burning, should help assure the survival of these sensitive habitats.

As for the plant poachers, legislation prohibiting the sale of carnivorous species is probably the best defense. The second best defense would be to plant "snake trees" around the periphery of each preserve.

Correction

In the November/December *News* it was erroneously stated that Richard and Lucile Durrell's work in Ohio "resulted in the founding of the Ohio Chapter." For years the Durrells have been key figures in the chapter's growth and development; however, the chapter was founded long before they became involved.

Gray bat

California

CASTLE ROCK (Del Norte County). This rocky island is the set for a cast of thousands, including tufted puffins, murres, guillemots, and rhinoceros auklets. Here in the coastal waters of extreme northern California lies the single spring staging area for Aleutian Canada geese—and one of the state's two greatest seabird rookeries, hosting some 150,000 breeding birds each year. Elephant seals and other marine mammals use the island's beaches as a "hauling out" site. The 13-acre preserve will be transferred to the U.S. Fish and Wildlife Service for protection of its wildlife and the restoration of its unusual coastal grasses.

Colorado

ANIMAS CITY MOUNTAIN (La Plata County). From meadows interspersed among open, park-like stands of ponderosa pine, one can look west to the La Plata Mountains or east across the Animas Valley to Missionary Ridge. This 300-acre property, rising steeply in rugged sandstone cliffs to conifer forest, is the dominant scenic feature viewed from the City of Durango, just to the south. Because it provides critical elk wintering and calving grounds—and counts among its other inhabitants the lynx, bobcat, and coyote—the tract will be incorporated in the Perins Peak Wildlife Area, a Bureau of Land Management administered area west of it.

Connecticut

KATHARINE ORDWAY PRESERVE (Fairfield County). The late Katharine Ordway, one of the Conservancy's most committed and generous supporters, bequeathed this 62-acre woodland close to her home for dedication as a new preserve. Appointed the Conservancy's first "land guardian" in 1978 by the Board of Governors, Miss Ordway made a remarkable contribution to the cause of conservation, including: creation of the five-state Ordway Prairie Reserve System (the most extensive grassland sanctuary system in the nation), a major gift to the Virginia Coast Reserve, and support for the establishment of the 1,500-acre Lucius Pond Ordway/Devil's Den Preserve, which lies near this new sanctuary. Management will be directed by the Devil's Den Preserve Committee.

Delaware

GREAT CYPRESS SWAMP (Sussex County). This 539-acre portion of the largest contiguous forested area in Delaware is a gift from the Chesapeake Corporation of Virginia. One of the state's two southern bald eagle families nests here and

hatched a healthy eaglet in 1979. Wooded swampland (bald cypress and red maple) predominates, but approximately 10 percent of the property is upland forest of oak, beech, and loblolly pine trees. Some ninety bird species are found in the swamp, including the Swainson's warbler. Great Cypress will be transferred to Delaware Wildlands, Inc., for management.

Florida

GREAT WHITE HERON NATIONAL WILDLIFE REFUGE—Addition—(Monroe County). A Gulf Coast island of red, black, and white mangroves, buttonwood trees, and cabbage palmettos has been acquired by the Conservancy for inclusion in this key bird sanctuary—critical to the great white heron, white-crowned pigeon, roseate spoonbill, and others. The Monroe County tract augments Conservancy-acquired additions to the refuge, which include Snipe and Porpoise Keys, by 80 acres.

PATRICIO ISLAND (Lee County). This island comprises 108 acres of mangrove swamp and marsh, edged on two sides with West Indian hardwood hammock. Vegetation includes wild coffee, Jamaican dogwood, sea grape, banyan, gumbo limbo, and poinciana trees. Several shell mounds, some 25 feet high, stand witness to native American habitation in prehistoric times. A number of wading birds nest here, while the island's waters offer feeding and resting sites for other species—the brown pelican, cormorant, and roseate spoonbill among them. Though uncommon elsewhere in the state, eastern indigo snakes and osprey are found on Patricio, as are impressive numbers of gopher tortoises. The island will be managed by the U.S. Fish and Wildlife Service as part of the existing Pine Island National Wildlife Refuge.

Maryland

MATTAWOMAN CREEK (Charles County). The Conservancy has assisted the State of Maryland in protecting 1,369 acres of swamp and floodplain forest west of the Chesapeake Bay. Named for a clear, meandering creek that empties into the Potomac River's tidal marshes, Mattawoman sustains a bird community of extraordinary diversity and productivity—and is an important spawning and nursery area for a number of fish species. Habitat for deer, beaver, mink, muskrat, raccoon, and river otter, the property will be managed by the state's Department of Natural Resources as an addition to the Mattawoman Natural Environment Area.

Massachusetts

GREAT MEADOWS NATIONAL WILDLIFE REFUGE (Middlesex County). A wooded hill and fields along the Sudbury River—entirely surrounded by town, state, private, and federal conservation lands—have been acquired by the Conservancy for inclusion in the adjacent Great Meadows refuge. Buildings on the 66-acre property, used since 1967 as an environmental education facility by the Elbanobscot Foundation, will serve the same function for the U.S. Fish and Wildlife Service, as well as providing headquarters for the refuge.

Michigan

HARBOR ISLAND (Chippewa County). Like a great broken ring cast in Lake Huron's Potagannissing Bay, this forested 695-acre island curves around calm waters and nearly meets itself. Here on the eastern end of Michigan's celebrated Upper Peninsula, thousands of ducks pause in their migrations, and osprey, harriers, Cooper's hawks, and bald eagles find refuge. Mature stands of northern hardwoods share the uplands with conifers. Islanders include coyotes, otters, muskrats, bears, foxes, and several colonies of beavers. The Conservancy will be working with the U.S. Fish and Wildlife Service on a long-range management plan for the area.

HOLLOWAY RESERVOIR—Addition—(Genesee and Lapeer Counties). An addition of 13 acres brings this protected area in eastern Michigan to 1,342 acres—woodland significant for its water frontage, its blend of northern and southern tree species, and its rich variety of herbaceous plants and shrubs. Holloway is managed by the Genesee County Parks and Recreation Commission.

Minnesota

NORTH STAR LAKE (Itasca County). One of the most successful bald eagle breeding areas in the Chippewa National Forest, this 24-acre inholding contains two eagle nests. One of these has fledged 13 eagles since its discovery in 1964. The property will be managed by the U.S. Forest Service as part of its existing Bald Eagle Territory, a special area designated for the bird's protection.

REGAL MEADOW (Kandiyohi County). Lavish with small white lady's slipper orchids, this 80-acre fen-like prairie in central Minnesota ranges from cattail marsh and sedge meadows on wet sites to little bluestem and typical tall prairie grassland in its drier precincts. Seen from the air,

Nags Head Woods

Nestled among the back barrier dunes of North Carolina's Outer Banks, a maritime forest of oaks and hickories—some as old as 500 years—spans the shoreline of Roanoke Sound.

Designated a National Natural Landmark in 1974, Nags Head Woods in Dare County sustains a highly unusual ecosystem fostered by the convergence of warm Gulf Stream waters and cold currents from Labrador. Both northern and southern plant species have flourished here, a number of them at their geographic limits.

Below the woodland with its 60-foot canopy of broad-leafed trees, wetlands abound. Fresh water trapped inland has formed ponds, swamps, thickets, and subterranean reservoirs —protecting the Woods against drought and contributing to the area's exceptional biological diversity.

Five state endangered plants, 13 state endangered birds, and 17 plant species considered by Cape Hatteras National Seashore to be rare or endangered on the Outer Banks thrive in the area's marshes and pine hammocks, and on its oak ridges and dunes. Notable among the resident fauna are river otters, muskrats, and diamondback terrapins.

All told, Nags Head Woods extends across 1,900 acres: an expanse in which more than half of the 120 distinct biotic communities found on the state's Outer Banks are represented. The North Carolina Heritage Program identified the Woods as a top protection priority; and the Conservancy—having ranked it one of the 20 most significant unprotected natural areas in the nation—has already acquired 223 acres there and protected three adjacent tracts through other means.

The North Carolina Nature Conservancy is presently approaching the halfway mark in its $600,000 fund-raising campaign for this outstanding new preserve, which will be managed by a volunteer stewardship committee.

the gently undulating outwash surface of the lowest part of the valley has a braided appearance. Management of the preserve is the responsibility of the Minnesota Chapter.

SANDHILL CRANE MEADOWS—Addition—(Morrison County). Twenty acres of marshy meadow expand this 160-acre preserve eastward, providing supplementary nesting habitat for the greater sandhill crane. The area—comprising marsh, oak savanna, and open prairie islands—creates an outstanding habitat for a number of other species, including the green heron, the great blue heron, and the prairie white-fringed orchid. The tract will be leased to the Minnesota Department of Natural Resources Scientific and Natural Areas Program for evaluation.

Mississippi

MISSISSIPPI SANDHILL CRANE NATIONAL WILDLIFE REFUGE—Addition—(Jackson County). Twenty-six acres of gentle coastal plain extend the existing refuge, crucial protected habitat for the federally endangered Mississippi sandhill crane. A gift of International Paper Company, the property will be transferred to the U.S. Fish and Wildlife Service for management. A Conservancy acquisition of 1,700 acres in 1974 sowed the seeds of this national wildlife refuge, and the organization's involvement on this project totals 8,222 acres.

Missouri

VICTORIA GLADE — Addition — (Jefferson County). The addition of three acres to the only

protected natural area representing the region's glade plant community brings the preserve to 250 acres. Its oak-hickory forest and cedar glade host 12 native grasses and 75 wildflower species. Management is directed by the Missouri Department of Natural Resources.

Montana

WILDHORSE ISLAND — Addition — (Lake County). This acquisition is one of 47 small lots on the perimeter of the 2,166-acre island preserve in Flathead Lake. Named for feral descendants of horses that the Flathead Indians sent there for safety during a Blackfoot raid, Wildhorse has steep inland ridges and cliffs rising to 1,000 feet above lake level. Most of the island was protected in 1977 in a cooperative effort with the Montana Fish, Wildlife and Parks Department, which is responsible for managing the area—including this half-acre addition.

New Mexico

GILA NATIONAL FOREST—Addition—(Grant County). The Turkey Creek-Gila River addition to the Southwest's great Gila National Forest spans 117 acres and nearly a full mile of the river itself. More than half of all bird species found in New Mexico can be seen in this rugged riparian environment of the Gila at Turkey and Mogollon Creeks. Turkey Creek bridges two distinct floodplain plant communities: a sycamore-cottonwood association near the river channel, and mesquite-dominated vegetation on the deeper sand and drier sites. Above the river, the loose rock of steep canyon walls runs to earth sparsely grown with one-seed juniper, sotol, and bear grass. The tract adjoins the southwestern corner of the Gila Wilderness Area, the nation's first designated wilderness, and will be managed by the U.S. Forest Service.

New York

WADING RIVER MARSH PRESERVE—Addition—(Suffolk County). With this 14-acre gift of Dorothy C. Kempf, the preserve now stands at 77 acres. The addition of heavily wooded property along the southern and eastern edges of the marshland will shield the preserve from developed areas beyond and enrich its natural diversity with contrasting upland habitat. Wading River Marsh is managed by the Conservancy's Long Island Chapter.

Oregon

NESIKA BEACH (Curry County). This last choice stretch of southern Oregon coastal forest, judged by the state's Natural Heritage staff to be one of its top five acquisition priorities, encompasses 36 acres of coastal bluff and headland overlooking the Pacific. Along with conifer woodlands, the preserve—a gift of Cynthia and Irving Lord—embraces marsh and rocky intertidal shoreline. Stewardship of the area will be directed by the Conservancy's Oregon Chapter in conjunction with a preserve management committee.

NORTH PINE CREEK (Baker County). In the northeastern part of the state, 323 acres of wooded, mountainous terrain and open grassland along North Pine Creek have been acquired in two parcels. The first tract, an inholding in the Wallowa-Whitman National Forest, and the west half of the second tract will be transferred to the U.S. Forest Service for management as part of the Hell's Canyon National Recreation Area. The creek itself, small and clear with numerous deep pools, sustains healthy populations of native rainbow and Dolly Varden trout.

Washington

LOOKOUT MOUNTAIN (Kittitas County). Bearing the marks of volcanic and glacial events—from the huge basalt blocks at its base to its precipitous, windswept west slope—this conservation easement protects a curious array of environments. Alongside conifer forests with a rich understory of grasses and flowering herbs stretch sagebrush scablands, defining a transition zone of keen interest to scientists. Two plants proposed for federally endangered and threatened status are found here, as are a variety of birds, including white-headed woodpeckers and vesper sparrows. Easement donors George and Natus Fahey and Paul and Helen Kirk have made a further gift to the Conservancy to finance conservation monitoring of the 480-acre property.

SENTINEL ISLAND (San Juan County). The last of the San Juans to be homesteaded, 15-acre Sentinel bears few signs of the small family cabin built there in the early 1900's. Its rocky shores border exposed grasslands of Idaho fescue, brome, and velvet grass, and its mixed forests contain the Pacific Coast's smooth-barked, ever-green arbutus. Harbor seals and river otters slip through Sentinel's waters, and bald eagles keep a nest in its woods. Having successfully completed its fund-raising campaign for the purchase of Sentinel, the Washington Field Office is presently working toward its $335,000 goal for acquisition of nearby Yellow Island and stewardship of both of these "islands of life."

NEW CONSERVANCY PRESIDENT NAMED

Patrick F. Noonan (left) and William D. Blair, Jr.

On April 9th, the Board of Governors named William Draper Blair, Jr.—a member of the Board since 1972 and its chairman from 1975-6—president of The Nature Conservancy. Blair succeeds Patrick F. Noonan, who announced his resignation in January after seven successful years in that position. (This issue of the *News* has been held from press for two weeks pending the appointment.)

Blair, whose conservation background includes service as president of the Audubon Naturalist Society of the Central Atlantic States, is currently a trustee of the Conservancy's Maryland Chapter. He is leaving his post as deputy assistant secretary for public affairs with the U.S. Department of State to head up the Conservancy staff.

Before joining the State Department in 1959, Blair, a graduate of Princeton University, was chief of the Paris Bureau of *Newsweek*. He had also reported as that magazine's London correspondent, directed its Bonn Bureau, and acted as assistant editor for international affairs. Prior to his work for *Newsweek*, Blair was a writer for the *Baltimore Sun* papers.

In announcing the appointment, Board of Governors chairman Frank Boren said: "Bill Blair's strong personal skills, his management experience, and his intimate working knowledge of the Conservancy uniquely qualify him to serve as our new president."

Boren went on to say: "We owe much of our success in the 70's to the inspiration, leadership, dedication, and truly outstanding performance of Pat Noonan. It is, perhaps, the clearest sign of his achievement that we are entering the 80's with a very firm financial base, a well-constructed long range plan, a solid organizational structure, and—most importantly—one of the finest assemblages of staff and volunteer talent of any organization I've observed in the nonprofit sector."

Cougars, orchids, eagles, pines: The Nature Conservancy is working to save the best of the last of what's left.

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Corrections

The Kentucky Chapter was omitted from the list of Conservancy chapters and committees in the January/February *News*. The chairman and his address are: Dr. William Bryant, 71 Dudley Road, Edgewood, Kentucky 41017.

In the January/February New Projects section, Tettegouche was inadvertently listed under Michigan. The preserve is in Lake County, Minnesota.

PHOTOS: Roger W. Barbour, pp. 18, 26; Susan Bournique, p. 28; Thomas M. Goodwin, p. 14; Conrad N. Hillman, pp. 20-22; John D. Luke, p. 4; Paul E. Moler, p. 12; Phil and Judy Sublett, pp. 6-9; Merlin D. Tuttle, p. 16; Kirtley-Perkins Photography, inside front cover.

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